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Cerebral Diagnostic and Therapeutic Angiography for Neonatal Arteriovenous Fistulas

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Summary

Cerebral diagnostic and therapeutic angiography for neonatal arteriovenous fistulas is reported. Three neonatal boys with vein of Galen aneurysmal malformation (1 patient) and dural arteriovenous fistulas (2 patients) presented severe congestive heart failure soon after birth, and were treated by transarterial and/or transvenous embolization using various access routes. In the neonatal period, umbilical approach and direct cervical approach provide unique access routes in addition to the usual transfemoral route. Characteristics of neonatal angiography are discussed.

Introduction

Congenital cerebrovascular diseases, which require diagnostic and therapeutic cerebral angiography in the neonatal periods, are vein of Galen aneurysmal malformations (VGAMs) and dural arteriovenous fistulas (AVFs), and less frequently cerebral arteriovenous malformations and/or fistulas [1-4]. Invasive catheter angiography is not indicated solely for the diagnosis, for which ultrasound imaging, x-ray computed tomography (CT), and magnetic resonance (MR) imaging and MR angiography are less invasive alternatives. We present our experiences in diagnostic and therapeutic cerebral angiography for the neonatal AVFs.

Case Presentation

We have treated three neonates with high-flow AVFs in the neonatal periods. These neonates required emergency embolization because of severe congestive heart failure using various access routes.

Case 1: This neonatal boy with a choroidal type of VGAM underwent transfemoral arterial embolization using interlocking detachable coils on postpartum day four and six. The femoral arterial sheath was left in place between these days. Although marked reduction of the arteriovenous shunts was obtained, the patient died on day 12 due to pulmonary haemorrhage [5].

Case 2: This neonatal boy with a dural AVF at the extremely enlarged torcular herophili was treated through umbilical venous route. The umbilical venous approach allowed transcardiac, arterial embolization as well as transvenous embolization. Four coil embolizations on postpartum day 4 (transumbilical, transcardiac arterial), 10 (transumbilical, transcardiac arterial), 12 (transfemoral arterial), and 17 (transumbilical venous) were performed to control severe heart failure [6]. A 5F vascular sheath placed in the umbilical vein was removed after the fourth embolization on day 17. The patient is now 4 years old and developed normally except for slight mental delay.

Case 3: This neonatal boy with a dural AVF associated with a huge dural lake in the left posterior hemisphere was born in the low-birth-weight state, 2,135 g (figure 1-A). This precluded transfemoral arterial approach. On the day of delivery, left retrograde radial angiography was performed to obtain gross vascular information of the lesion. Transfemoral venous coil embolization was performed on postpartum day 1 (figure 1-B). Transarterial glue embolizations by direct carotid puncture after surgical exposure were further necessary on day 7 (left side), 23 (right side), and 42 (left side again) to control severe heart failure (figure 1-C). At 7 months old, ventriculo-peritoneal shunt for the associated hydrocephalus was performed. This patient is now 8 months old and has slight right hemiparesis with slight mental delay.

Discussion

Characteristics of Diagnostic and Therapeutic Angiography in the Neonatal Period[7]

Antenatal ultrasound diagnosis is useful for detection of VGAM and dural AVF in the latter half of the pregnancy. MR imaging may confirm the ultrasound diagnosis. Cerebral AVM or AVF may be discovered soon after birth, but this situation is extremely rare. Antenatal diagnosis of either VGAM or dural AVF does not always indicate the necessity of emergency embolization. Brain haemorrhage, infarction, and calcification mean severe brain damage. Cerebromalacia caused by persistent venous hypertension is called "melting brain syndrome". Invasive catheter angiography is only indicated when therapeutic intervention is required. Less invasive imaging (ultrasound, CT, and MR) may provide sufficient information to manage the neonates medically. The purpose of intervention in the neonatal period is not the anatomical cure or disappearance of the disease, but to improve the clinical status. Although there is no apparent end point to each embolization, slight reduction of arteriovenous shunts occasionally improves clinical status drastically.

Instead of saline, 5% dextrose is used as maintaining fluid to avoid excess electrolyte. Total dose of contrast material is strictly limited up to 6 ml/kg weight, but in the state of renal and heart failure, further reduction of the contrast is necessary. To reduce the dose, biplane equipment is required. Manual carotid compression may help to visualize the contralateral carotid tree. To obtain the whole brain angiograms in the second contrast circulation, image acquisition time should be prolonged to 15 seconds. Even with poor images in the second circulation, important information might be obtained. Contrast material in the dead space of the catheter after each injection should be removed to reduce a total dose of the contrast.

Transfemoral Arterial Approach

Diagnostic angiography for the neonates is performed with a 3F diagnostic catheter without a vascular sheath. The configuration of the catheter tip is a simple vertebral or Berenstein. For intervention, a 4F vascular sheath should be placed into the femoral artery. This 4F catheter is used as a guiding catheter even in the neonates. Internal carotid or external carotid artery has a loop and/or elongation frequently due to increased blood flow, for which a flow-guided microcatheter is required to reach the target vessels. Because cerebral arteries in the neonates are fragile, gentle catheter manipulation is necessary. If repeated intervention is required within a few days (mostly next day), a vascular sheath can be left in the femoral artery as occurred in Case 1. Careful observation of leg ischaemia is mandatory, and immediate removal of the sheath is necessary when leg ischaemia is apparent. Femoral puncture is performed alternately to the right and left femoral arteries. In the case of the low-birth-weight neonates, femoral artery is extremely small, and not well developed because of the compromised blood flow in the descending aorta cause by large arteriovenous shunts. If birth weight is lower than 2,500 gr and intervention is indicated, transfemoral arterial approach should be avoided.

Transradial Retrograde Diagnostic Angiography

It is possible to perform retrograde radial angiography using the 24G needle placed at the radial artery, which is used for blood pressure monitoring and blood sampling. Only diagnostic angiography is possible from this route. Even with retrograde left vertebral angiogram,

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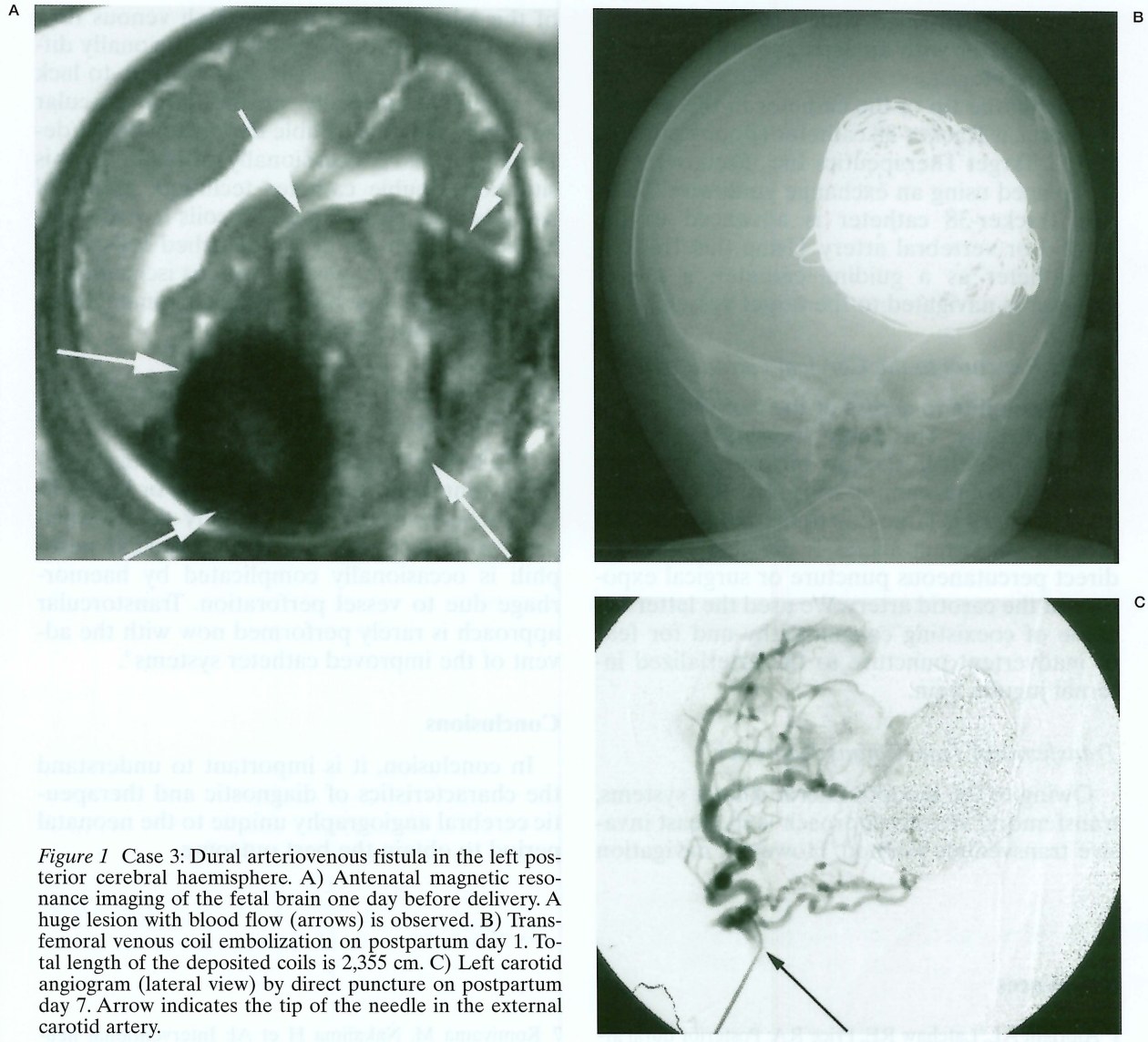

Figure 1 Case 3: Dural arteriovenous fistula in the left posterior cerebral haemisphere. A) Antenatal magnetic resonance imaging of the fetal brain one day before delivery. A huge lesion with blood flow (arrows) is observed. B) Transfemoral venous coil embolization on postpartum day 1. Total length of the deposited coils is 2,355 cm. C) Left carotid angiogram (lateral view) by direct puncture on postpartum day 7. Arrow indicates the tip of the needle in the external carotid artery.

left carotid information might be available due to well developed collateral from the left vertebral artery. Carotid compression and/or prolonged imaging of the second circulation are useful in this situation.

Transumbilical Approaches

There are two small umbilical arteries and one large umbilical vein, which are located in the spiral fashion in the umbilicus. Transumbilical angiography is possible through these vessels. Although it is not easy to catheterize these vessels, it should be attempted soon after birth. A 4F vascular sheath or a nutritional tube can be put into the umbilical vessels. Umbilical artery should be catheterized as early as possible since constriction may ensue. Using an umbilical arterial route, arteriography is possible. Since the course of the umbilical artery to the internal iliac artery and aorta makes sharp angle along each side of the bladder, the vascular sheath should be kink-resistant.

Venography is possible through the umbilical vein, which connects with the ductus venosus and inferior vena cava. Also, arteriography is possible when the catheter is navigated from the right atrium to the left one through the foramen ovale, and to the left ventricle, and then to the ascending aorta [6]. Transcardiac catheter na-

vigation is performed with a balloon-tipped 4 or 5F catheter with an assistance of the paediatric cardiologist.

Placing the tip of the catheter in the ascending aorta, a Tracker-38 catheter (floppy portion: 20 cm, Target Therapeutics Inc., Fremont, CA) is replaced using an exchange guidewire. Then, this Tracker-38 catheter is advanced to the carotid or vertebral artery. Using this Tracker-38 catheter as a guiding catheter, a microcatheter is navigated to the target vessels.

Direct Puncture to the Cervical Carotid Artery

It is possible to access of the cervical carotid artery directly. This route is useful when the neonate is born in the low-birth-weight and/or umbilical route cannot be used. Usually, the carotid artery is large due to increased cerebral blood flow. Direct access is possible either by direct percutaneous puncture or surgical exposure of the carotid artery. We used the latter because of coexisting coagulopathy and for fear of inadvertent puncture to the arterialized internal jugular vein.

Transfemoral Transvenous Approach

Owing to the modern microcatheter systems, transfemoral venous approach is the least invasive transvenous method. However, navigation of the microcatheter against high venous flow in the cerebral venous sinus is occasionally difficult since the catheter is unstable due to lack of stability, especially in the large torcular herophili. Similarly, stable deposition of the detachable coils is occasionally difficult. In this situation, double catheter technique is useful using two separate large 3-D coils to avoid unexpected migration of the detached coils. A 4F femoral sheath may cause venous ischaemia of the leg in the low-birth-weight neonate when placed for a long time[7].

Direct Puncture to the Cerebral Venous Sinus, Torcular Herophili, or the Lesion Itself

The lesion is accessible by puncturing the anterior fontanelle, torcular herophili or lesion itself through a burr hole or bony defect when present. Direct puncture of the torcular herophili is occasionally complicated by haemorrhage due to vessel perforation. Transtorcular approach is rarely performed now with the advent of the improved catheter systems[9].

Conclusions

In conclusion, it is important to understand the characteristics of diagnostic and therapeutic cerebral angiography unique to the neonatal period to obtain the best outcome.

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